

The Electrochemical Characteristics of Mo/AlNd Thin Film in TMAH Solution

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Although there are many advantages such as low electrical resistivity, low material cost, high adhesion, and superior pattern formation for Al as a conducting material for thin-film transistor liquid crystal display (TFT-LCD), Al is susceptible to stress-migration phenomena [1]. Therefore, the hillock and whisker would form at the surface of the Al film during high temperature processes such as the deposition of insulator films by CVD [2]. Because the hillock would degrade the quality of the metal thin-film line, several approaches have been proposed. Among these, cap by a stiff overlayer [3-4] and formation Al alloy [5] are considered to be the most effective methods to solve the hillock problem. After the deposition of Al film, the lithography processes which include photoresist coating, soft-baking, exposure, development, and hard-baking would be proceeded to form the interconnection pattern of LCD. The tetra-methyl ammonium hydroxide (TMAH) is now widely used as the photoresist developer.

In this study, the two-layer thin film of molybdenum (Mo) layer over the 300 nm aluminum-neodymium (Al-Nd) alloy film with a nominal Nd composition of 2 at.% were deposited on glass substrates by DC magnetron sputtering with an argon gas pressure at 0.3 Pa and the substrate temperature at 120 °C. However, it was found that the blemishes were appeared after five minutes immersion in 2.38 wt% TMAH solution for the thickness of Mo-capped layer was 25 nm as shown in Fig. 1.

For this work, the origins of the blemishes were investigated in alkaline TMAH solutions by the electrochemical corrosion techniques and AC Impedance measurements. Scanning electron microscopy (SEM) was used to examine the surface of the two-layer thin films before and after immersion.

The experimental conditions are listed in Table 1. Experimental results, as shown in Table 2, indicate that increasing the thickness of the Mo layer causes a decrease in the corrosion current density (I_{corr}) and an increase in the corrosion potential (E_{corr}). With increasing the thickness of the Mo-capped layer, the corrosion behaviors of the two-layer films are gradually close to pure-Mo single metal layer. Furthermore, the similar results have also been obtained from the values of the charge transfer resistances (R_{ct}) in which the behavior of the two-layer films/electrolyte interface can be understood by Impedance measurement. It can be deduced that the Mo-capped layers may be porous or the Al layers are too rough to be covered completely by Mo deposition. Therefore, in alkaline TMAH solutions, the bimetallic corrosion (galvanic corrosion) would occur. The mechanism of this bimetallic corrosion is based on the oxidation of Al atoms at the active regions as the result of exposure to the TMAH solution. It represents irreversible coupled corrosion reactions. The cathodic reaction at the surface of Mo layer is the reduction of water or oxygen to OH^- , and the anodic counterpart at the Al metal region, which are exposed to TMAH, is the formation of adsorbed $\text{Al}(\text{OH})_4^-$ ions or $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ which transforms from $\text{Al}(\text{OH})_3$ due to OH^- tightly adsorbed.

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Reference

1. D. K Kim, B. Heilandc, W. D. Nix, E. Arzt, M. D. Deala and J. D. Plummera, *Thin Solid Films*, **371**, 278 (2000).
2. M. Zaborowski and P. Dumania, *Microelectronic Engineering*, **50**, 301 (2000).
3. E. Iwamura, K. Takagi and T. Ohnishi, *Thin Solid Films*, **349**, 191 (1999).
4. T. Arai, A. Makita, Y. Hiromasu and H. Takatsuji, *Thin Solid Films*, **383**, 287 (2001).
5. E. Iwamura, T. Ohnishi and K. Yoshikawa, *Thin Solid Films*, **270**, 450 (1995).

Table 1 Experimental

Working electrode	Samples at Table 2
Counter electrode	Pt/Ti
Reference electrode	Hg/HgO, NaOH (1 M)
Potentiodynamic scan rate	5mV/s
AC Impedance	100 kHz to 0.01 Hz, 10mV at OCV

Table 2 The values of the corrosion potential (E_{corr}), the corrosion current density (I_{corr}) and the charge transfer resistance (R_{ct}) for different samples.

Samples	E_{corr} (V)	I_{corr} ($\mu\text{A}/\text{cm}^2$)	R_{ct} ($\Omega\text{-cm}^2$)
25 nm Mo/300 nm Al-Nd	-1.175	416.3	61
50 nm Mo/300 nm Al-Nd	-1.063	76.27	813
100 nm Mo/300 nm Al-Nd	-0.665	8.481	1757
50 nm Mo	-0.581	4.168	2139
300 nm Al-Nd	-1.836	118.8	179

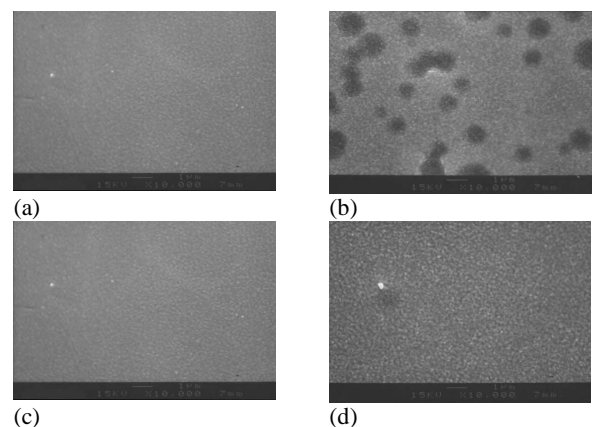


Fig. 1. SEM micrographs of: (a) 25 nm Mo/ 300 nmAl-Nd/Glass sample surface; (b) sample (a) after 5 minutes immersion in 2.38 wt% TMAH solution; (c) 100 nm Mo/ 300 nm Al-Nd/Glass sample surface; (d) sample (c) after 5 minutes immersion in 2.38 wt% TMAH solution.